Capability of Rolling Efficiency for 100M High-Speed Rails

DE-SC0010169

OG Technologies, Inc. / Georgia Institute of Technology

Arcelor Mittal Steelton / Republic Steel

July 2014 to Date

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Washington, D.C.

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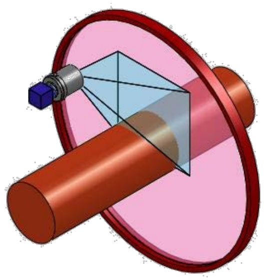
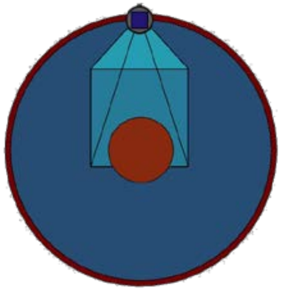
Project Objective

- Rail transportation is one of the most efficient way for mass transport over land. While being the pioneer to develop rail network in the early 1900, US has been lagging Asia and Europe in terms of high speed rail deployment. In April, 2009, President Obama announced a new vision for high-speed and intercity passenger rail service (HSIPR) in America to bring the US railway back into world class system.
- As the speed of trains increases, it demands much tighter tolerance on geometry and surface defects due to higher stress and safety concerns. The tighter specification is a challenge to the US-based rail manufacturers.
- This CORE project is aiming at establishing the capability for the US rail manufacturers to supply the high spec rails with a strong competitive edge in efficiency by practicing the rail manufacturing in a new paradigm with innovative sensor design and deployment, and process modeling.

Technical Innovation

- To overcome the complexity of trigonometry associated with traditional 3D triangulation, especially considering the noises caused by the temperature variation, harsh ambient environment, free object motion, and complex cross section contours, OGT developed an innovative optical configuration in the 3D triangulation that brings the imaging plane overlapping the laser plan, thus providing uniform optical property while keeping the depth of focus requirement.





- Additionally, the team includes the experts from the participating mills and Georgia Institute of Technology to develop a methodology based on meta-models, to overcome the complicated modeling challenge corresponding to the multistage manufacturing process, aiming at identifying process issues during the multi-stage manufacturing based on the process data and product data collected during the manufacturing process.

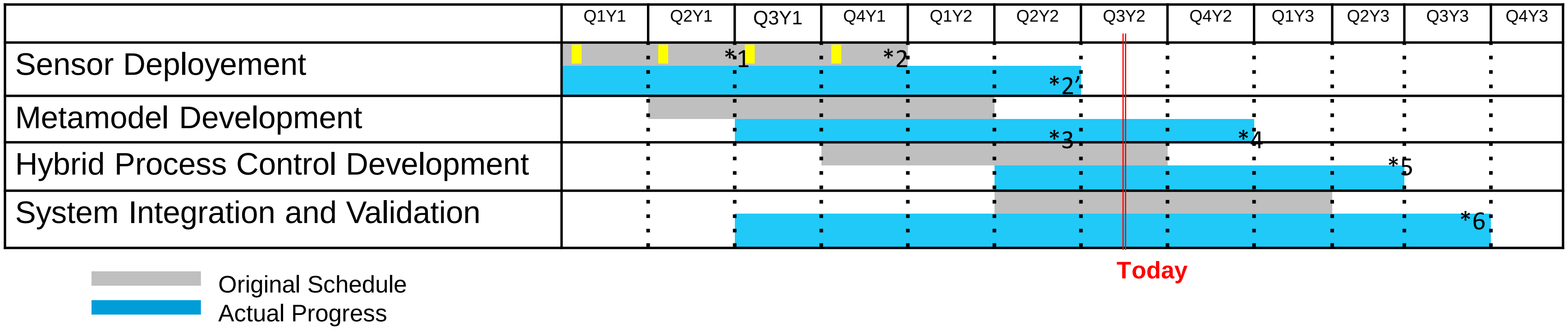
Technical Approach

- With its expertise in optical design and real-time signal process, OGT leads the project for sensor development of in-line surface inspection and in-line full profile measurement . The challenges it faces include the high geometric and surface condition variations, difficulty in hot rail/bar guidance, etc.
- Georgia Institute of Technology leads the team to develop a methodology to efficiently study the process and provide advances hybrid process control based on existing and developing sensor feedbacks and engineering knowledge of the process. The challenges it faces include the complicate non-linear and interacting process variables, limited available control variables, etc.
- The participating mills provide the production facility, available process data, and their engineering knowledge to the system development.
- The participating mills also install, operate, maintain the test units and review the data to help refine the CORE system hardware and software.

Transition, Deployment and Measurement of Success

- With past DOE fundings (DE-PS36-00GO10486; DE-FC36-04GO14003, DE-SC0001570), OGT has been providing inline optical inspection systems to the target industry for 40+ global installations during the past 10+ years. With these commercial installations, OGT developed an implementation process so that the mills could adopt the new sensor and utilize its data efficiently.
- As the objective is to provide a tool for steel mills to improve their process with advance sensors and data fusion, participating mills' engineers were integrated into the system development from the very beginning. In addition, the team also seeks feedbacks from other mills from past commercial relations.
- The test units be kept at and operated by the participating mills, as a demonstration site and test-bed for future fine-tuning and enhancements.
- The development progress has been shared with the team's current and future customers with its global sales network. Multiple mills have requested commercial proposals. The team also has been actively seeking additional industrial and government partners to further expand the sensor technology and Metamodel methodology to other applications, such as high speed rolling, 3D printing, etc.

Project Management & Budget



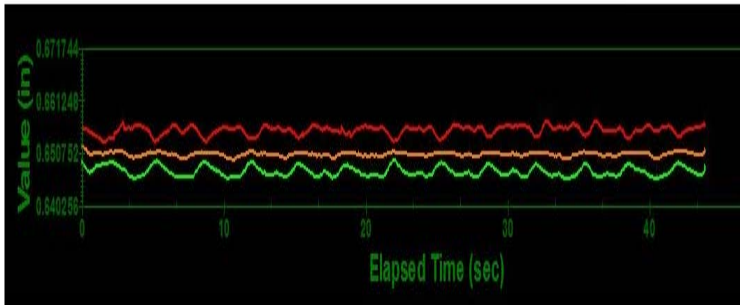
Total Project Budget (cash)	
DOE Investment	$999,999
Cost Share	$350,000
Project Total	$1,349,999

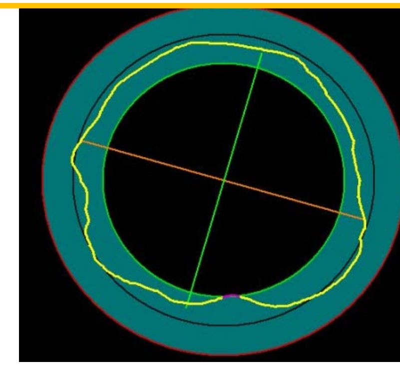
*In-kind contribution over $2 millions.

Results and Accomplishments

Sample of Typical Rail Defects

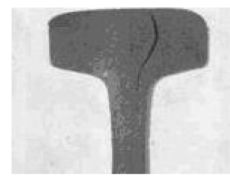
Detected by Profile Measurement Sensor





Roll Marks

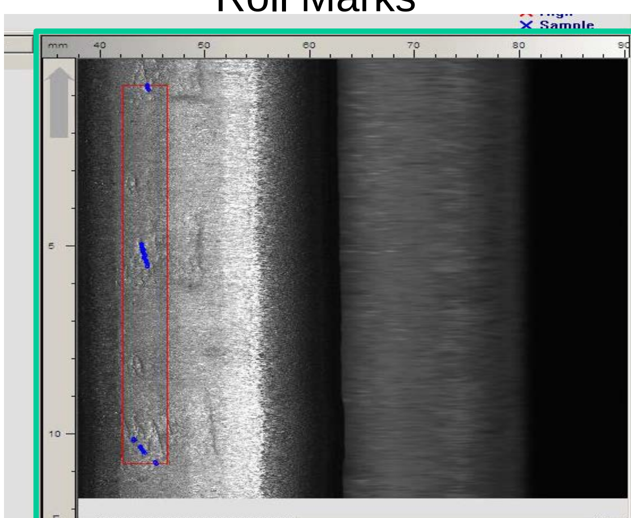
Hook/Vibration

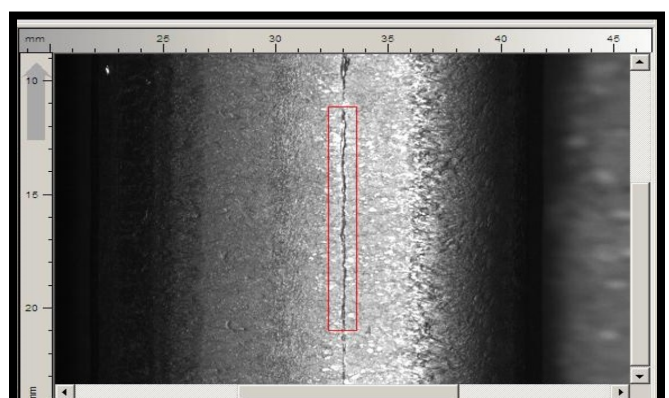


Cracks

Underfill

(a sample from round section was shown here for enhanced error display.)





Detected by Surface Inspection Sensor

Results and Accomplishments

Gauge R&R of the Profile Measurement Sensor

Rail Unit

	σ	6σ	Control Range	Spec Range
Repeatability	0.0167 mm	0.1 mm		
Reproducibility	0.0347 mm	0.208 mm	0.4~1.2mm *	0.67~1.78mm *

* Different dimensions on the rail have different dimension tolerances.

Wire/Rod Unit

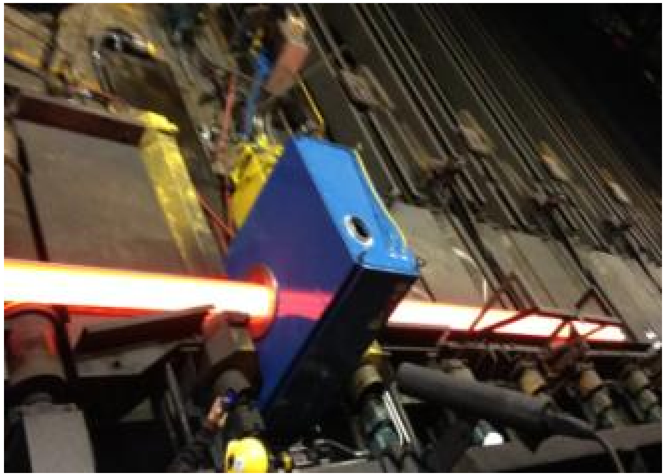
	σ	6σ	Control Range	Spec Range
Repeatability	0.0033 mm	0.02 mm		
Reproducibility	0.0049 mm	0.03 mm	0.18~0.2 mm	0.36~0.41 mm

Repeatability: Measurement variations when comparing the parts were measured at the same locations.

Reproducibility: Measurement variations when the parts were moved within confinement of existing hot steel guidance during normal production conditions across the size range of the corresponding mill.

Results and Accomplishments

Rail Unit Installation



Arcelor Mittal – Steelton, Pennsylvania, Installed November 2015

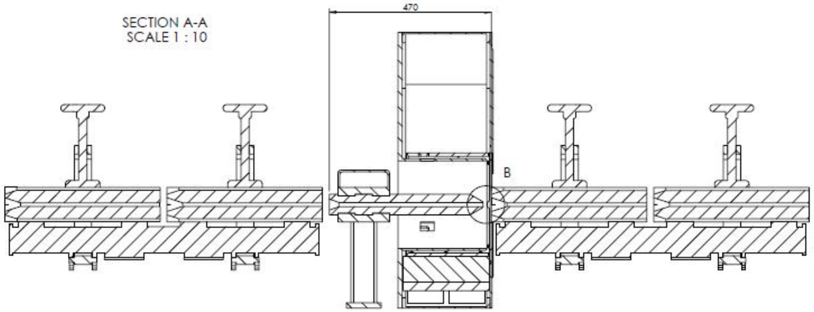
Results and Accomplishments

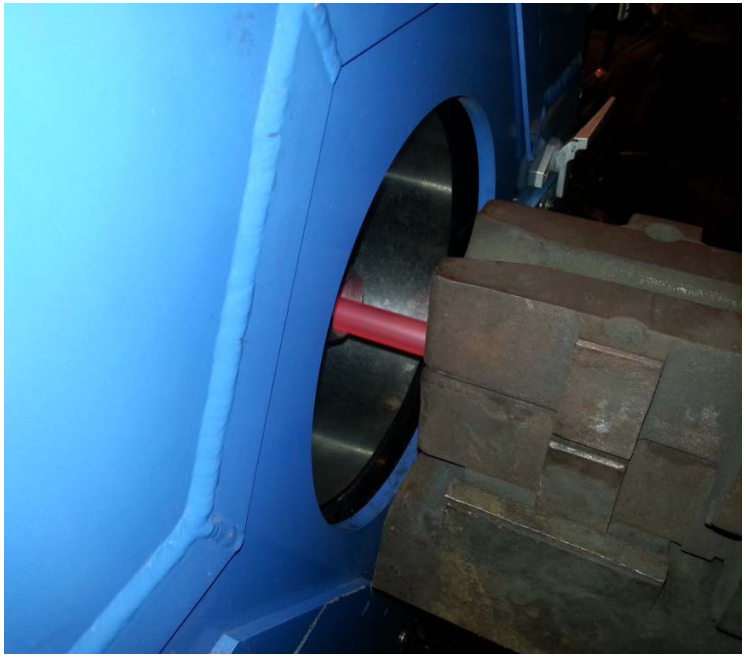
Rail Unit Results

Arcelor Mittal – Steelton, Pennsylvania, Installed November 2015

Results and Accomplishments

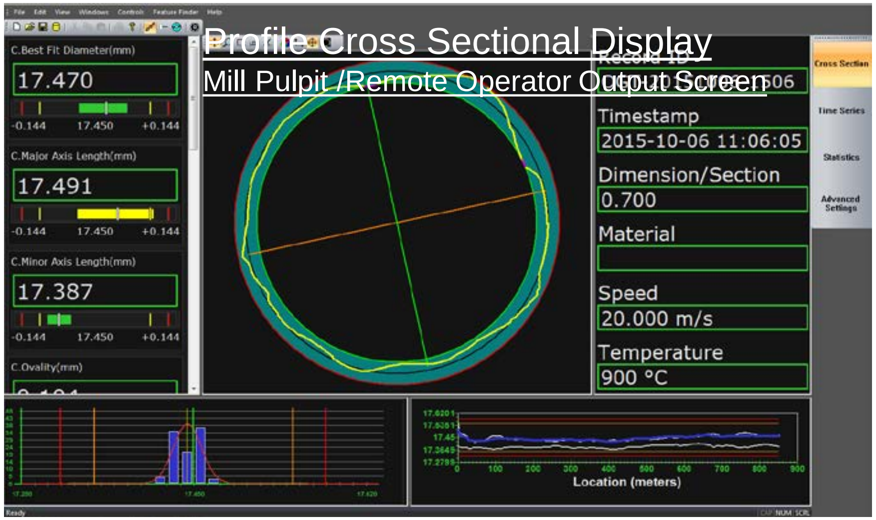
Wire/Rod Unit Installation (Rolling speed is 65m/sec, Funded by OGT)





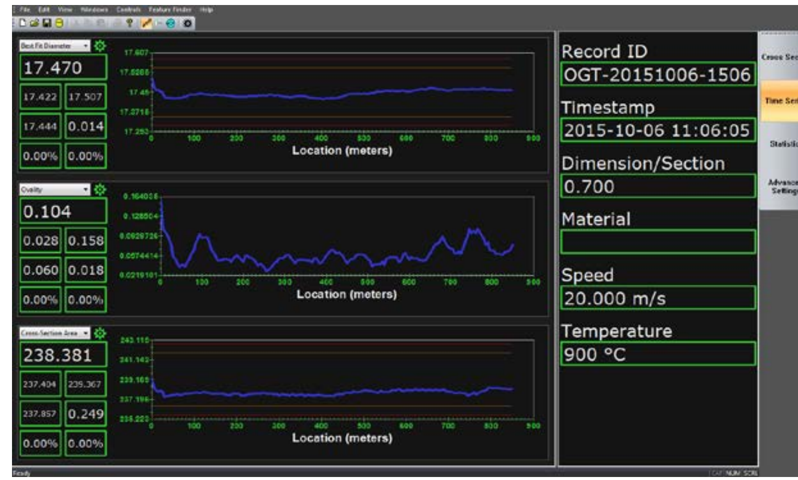
Results and Accomplishments

Wire/Rod Unit Results

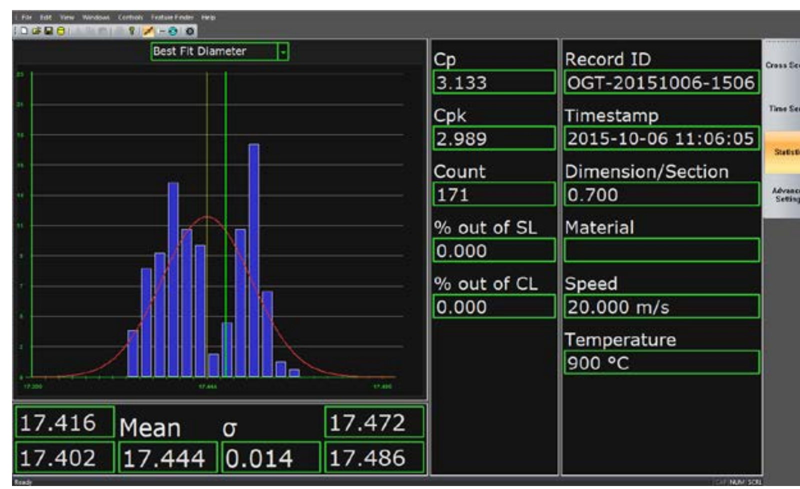


Profile Cross Sectional Display
Mill Pulpit /Remote Operator Output Screen

Time Graph View – Review
up to 4 rolled variable per bar can be view post rolling



Profile Monitor™
-rolled bar grading and performance tracking



PPS™ 221 Republic Steel, Lorain, Ohio, Installed June 2015